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ABSTRACT

A number decomposition game (DECO) was investigated in two versions of the game using the same arithmetic operations but differing in their structure of interdependence. The structure of interdependence is defined as the relationship of competition or cooperation between players and the criteria for successful attainment of game goals as defined by pre-established rules. Subjects for the study were 64 second and third grade students at two public elementary schools in Geneva, Switzerland. A two-way analysis of variance was used on grade crossed with game version as measured by percent of interactions, percent of mutual monitoring and control, adequacy of decomposition strategy, and percent of errors. For percent of interaction, all three effects--grade, game version and their interaction--were significant. For monitoring and control, all were non-significant. For decomposition strategy, game was significant and for errors, game version was significant. Quantitative indicators of congruence of playing behavior with game rules, monitoring and control, and decomposition were examined by regression analysis. Quantitative and qualitative measures were used to identify player profiles for both versions of the game. These player profiles did not appear to have a systematic impact on game outcome. (JM)

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COMPETITION AND COOPERATION IN THE CONTEXT OF GAMES USED FOR MATHEMATICS INSTRUCTION

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In recent curriculum reforms in the area of elementary school mathematics instruction, games are often advocated as a means of stimulating active student involvement in the process of learning. Games, it is argued, provide an opportunity for discovery and/or application of mathematics concepts and operations, while at the same time fostering the development of higher-order competencies: reasoning strategies, monitoring and self-regulation behaviors, interpersonal skills. The impact of instructional games is likely to depend, however, on several factors:

- the articulations established between games and other instructional activities,
- the structure of the game, i.e., the rules governing relations of competition and/or cooperation between players,
- the way in which the game structure is transposed into game playing behavior, i.e., the interpretation (application, transformation) of the pre-established rules by different groups of players.

The research reported here is concerned with the role of the latter two factors in games played by second and third-grade students.

Although there is a sizeable body of research comparing individual, competitive and cooperative learning conditions in a variety of settings and subject matter areas, the results have not been fully convergent. Studies by Johnson and Johnson (1974; Johnson, Skon & Johnson, 1980) have shown positive effects of cooperative conditions for both classical school tasks and for problem solving situations. In other studies, however, competitive

reward structures have appeared to be more advantageous for learning (Michaels, 1977). Research on techniques of student-team learning, which generally combine cooperation within teams and competition between teams, has provided encouraging results (Slavin,1980), but the effectiveness of these techniques has not been demonstrated in some studies (Mevarech, 1985). Relatively few studies have examined competition versus cooperation in the context of instructional games used in elementary schools. One exception is the experiment by Ryan and Wheeler (1977) which investigated the effects of competitive and cooperative background experience on the subsequent game playing behavior of fifth-and sixth-grade students. In this study prior experience had a significant effect on the interactions between players (more cooperative behavior being observed among the children with pre-game experience of cooperation), but differences in patterns of player interaction did not lead to significant differences in game outcomes. Obviously, a good deal more research is needed to determine whether competitive or cooperative patterns of interaction have an influence on the types of skills acquired by children through instructional games

OBJECTIVES OF THE PRESENT STUDY

The study presented here is part of a larger-scale investigation of how students in the early years of elementary school function when they play games as a "duo", without constant teacher supervision, in the context of mathematics instruction (Allal, 1981, 1985).[1] This paper focusses on the experimentation of a game of number decomposition ("DECO") with second- and third-grade children. The experiment is based on two versions of the game which entail the same arithmetic operations but which differ with respect to their <u>structure of interdependence</u>, i.e., the relationship of competition or cooperation between players and the criteria for successful attainment of game goals, as defined by a set of pre-established rules. In one version of DECO, the rules imply competition between two opponents; in the other version, the rules imply a relationship of cooperation between two partners in order to attain a common goal.

A general hypothesis of our research is that any given <u>game structure</u>,

i.e., the game as defined by a set of pre-established rules, may be transposed into a variety of game situations, i.e., the game as played by different pairs of children. The analysis presented here is focussed on several aspects of this transposition process. More specifically, it attempts to answer the following questions:

1) Do the factors grade and game structure have a systematic impact on the children's game playing behavior and on the game outcomes ?

2) To what extent and in what ways do patterns of player interaction differ from the structure of interdependence implied by the rules of each version of the game ?

3) What are the effects of different patterns of player interaction (including transformations of game structure) on the children's mutual monitoring and control behaviors and on the adequacy of their decomposition strategies ?

METHOD

Subjects. Experimentation of the game DECO was carried out with 64 second- and third-grade students at two public elementary schools in the canton of Geneva (Switzerland). The schools were selected because they are representative of the elementary school population of the canton on the variables socio-economic status of the student's family and nationality (Swiss, non Swiss).

Game description. DECO is a board game for two players dealing with the operations of number decomposition. These operations, along with other additive operations, are part of the first-grade curriculum of mathematics instruction in French-speaking Switzerland. For second- and third-grade students, DECO provides an opportunity for consolidation of their competency in this area and for development of increased speed and flexibility of calculation. Although an adult may consider the decomposition of a number to be a single, simple arithmetic operation, for second and third graders, the task proposed by DECO entails several, relatively complex operations: the player has to search for a possible combination of numbers, find their sum (by counting or calculation), compare it to the number to be decomposed,

look for additional numbers (to complete the decomposition, or to replace previously selected numbers), check the result, etc.

Our experimentation is based on two versions of DECO which differ from the point of view of the structure of interdependence implied by the rules announced to the players at the beginning of the game sessions.

- competitive version: A round is composed of 10 turns, 5 turns per player in alternation. At the beginnning of each turn, the player draws an orange chip with a number (from 3 to 20) to be decomposed. The operation of decomposition is carried out using yellow chips, drawn at random, with numbers from 0 to 9 (including "jokers" that can take on the values 0-9). After selecting an appropriate combination of yellow chips among those available, the player places them on the game board next to the number to be decomposed. The purpose of the game is to use as many yellow chips as possible and to have as few as possible left at the end. Each player's score is calculated at the end of the round (number of chips placed on the board - number of unused chips), and the player with the highest score wins.

- cooperative version: The basic operations are identical to those of the competitive version. However, a round is composed of 5 turns. At each turn the two players are supposed to function as a team and carry out all operations in collaboration. A score is calculated for the team at the end of the round and the aim is to improve the team's score from one round to the next.

(A detailed description of the game material and rules appears in Annex A).

Design. Experimentation was conducted with a design in which the factor grade (second, third) was crossed with the two versions of the game (competitive vs. cooperative structure), and eight pairs of children were nested in each of the four conditions. The pairs were formed by the classroom teachers on the basis of their usual criteria for small group work, and were then randomly assigned to game version.

Data collection. Each pair of players was observed during four rounds of game play carried out in two sessions (two rounds per session). The observers did not intervene while the children were playing, even if they

made mistakes or did not follow the game rules, since one aim of the research was to study possible transformations of game structure introduced by the players. All gestures, manipulations of game material and verbal interventions or exchanges were recorded on two observation schedules by two observers. An audio recording was simultaneously made of the children's verbalizations in order that any "gaps" in the observation schedules could be filled in at the end of each session. The observations were completed by an interview with the players at the end of the fourth round. The data collected for each pair of players provides a very detailed protocol of their behavior during the game rounds. A more complete description of the data collected appears in Allal (1985).

Analysis. Each protocol was submitted to several coding procedures leading to the calculation of a series of quantitative indicators pertaining to different aspects of the children's game playing behavior. Relationships among these indicators were studied by regression analysis and the effects of grade and game version were tested by analysis of variance. In addition, each protocol underwent a screening process for qualitative indications that would aid in interpretation of the results of the statistical analyses or would permit refinement of the initial findings.

RESULTS

The results of this study will be presented under two headings: (1) effects of grade and of game version, and (2) patterns of player interaction and transformations of game structure. For each heading, the method of data analysis will be briefly described and the results, summarized in tables, will be discussed.

Effects of grade and of game version

A two-way analysis of variance (ANOVA) was carried out to determine the effects of the factors grade (2nd, 3rd), game version (competitive vs.

cooperative structure) and their interaction on four behavioral indicators. Two indicators pertain to processes of interaction between players during the game :

(1) INTOT (% of turns with verbal interaction or intervention by one or both players) is a measure of the regularity of the children's verbalizations in the course of game play;

(2) CONMUT (% of turns in which the decomposition operations carried out by one player are verified by the other player either during or at the end of the turn) indicates the degree to which the children engage in a process of mutual monitoring and control.

The other two indicators concern the results of the decomposition operations carried out by the players :

(3) DECOMP is a score on a scale of 0 to 40 points which measures the adequacy of the player's decomposition strategy (at each turn: 2 points - optimal decomposition according to the rules of the game, 1 point - non optimal but correct decompositon, 0 point - incorrect decomposition);

(4) ERCALC (% of turns with an incorrect decomposition) indicates the frequency of errors of calculation.

Table 1 presents the average scores on each indicator, by experimental condition, and gives the univariate F ratios for each effect: grade (G), game version (V) and their interaction (G x V).

For the variable INTOT, all three effects - grade, game version and their interaction - are significant. By examining the pattern of the average scores by condition, the following picture emerges of the children's verbal interactions while playing DECO. Under the cooperative version of the game, there are almost constant verbal exchanges and interventions, occuring at nearly every turn, by the players of both grades (INTOT - 95.6 & 95.0). This is coherent with the principle of cooperative play which implies discussion between partners to determine the operations to be carried out at each turn. Under the competitive version of DECO, the regularity of verbalization is lower (average of 73.3 for the two grades), but it is nevertheless quite high compared to typical adult competitive games (e.g. chess matches) which often take place virtually in silence. While the cooperative version shows no

Table 1 : Average scores and results of ANOVA for Grade x Game version

Average scores, by condition **Results of ANOVA**

Variable : **INTOT** (regularity of verbal interactions/interventions during game)

	Game version				
	Comp.	Coop.		Effect	F ratio
Grade 2	83.8	95.6	89.7	Grade (G)	5.662 *
3	62.8	95.0	78.9	Version (V)	23.575 *
	73.3	95.3	84.3	G x V	5.027 *

Variable : **CONMUT** (mutual control during and at end of turns)

	Game version				
	Comp.	Coop.		Effect	F ratio
Grade 2	78.4	62.5	70.5	Grade (G)	0.757
3	63.6	65.6	64.6	Version (V)	1.078
	71.0	64.1	67.6	G x V	1.789

Variable : **DECOMP** (adequacy of decomposition strategy)

	Game version				
	Comp.	Coop.		Effect	F ratio
Grade 2	31.6	33.1	32.4	Grade (G)	6.992 *
3	34.2	35.0	34.6	Version (V)	1.899
	32.9	34.1	33.5	G x V	0.168

Variable : **ERCALC** (errors of calculation)

	Game version				
	Comp.	Coop.		Effect	F ratio
Grade 2	7.4	1.9	4.7	Grade (G)	3.032
3	3.4	1.9	2.7	Version (V)	9.286 *
	5.4	1.9	3.7	G x V	3.032

*Significant F ratio at $p < .05$

difference between grades, under the competitive version there is a substantial decrease of verbalization between grades 2 and 3 (INTOT of 83.8 and 62.8, respectively). This suggests that the older children are beginning to adopt a style of play closer to the adult mode of tacit competition with little verbal interaction.

For the indicator CONMUT, the F tests for all three effects are non significant. This implies that despite the variations in the overall frequency of verbal interactions, as revealed by INTOT, children's mutual monitoring and control behaviors remain at a fairly stable level for the two grades and for the two versions of DECO under consideration. The level indicated by our data (i.e., mutual control occuring at approximately 2/3's of the turns) is probably an underestimate since CONMUT takes into account only observable behaviors and some verification operations are undoubtedly carried out mentally, particularly by third graders.

The indicator DECOMP reflects both the children's ability to calculate correctly and their capacity to formulate a strategy that is coherent with the goal of the game (i.e., carry out a decomposition using a maximum number of available chips). For this variable, the F test is significant for grade, but not for game version or for the interaction. The indicator ERCALC, measuring the frequency of errors of caculation, shows the opposite result: the effect of game version is significant, but those of grade and of the interaction are not. The data for these two indicators lead to the following picture of the players' mastery of the arithmetic operations involved in DECO.

Second and third graders manage equally well to carry out decompositions that are arithmetically correct. Errors of calculation are quite infrequent under the competitive version of DECO (5.4% of the turns) and are even more infrequent under the cooperative version (1.9 % of the turns). Errors of strategy (i.e., correct but non optimal decompositions) are somewhat more frequent in second than in third grade, as reflected by the second graders' lower DECOMP scores (32.4 vs. 34.6 for 3rd grade), but the adequacy of the children's strategies does not significantly differ between the competitive and cooperative versions of the game.

Patterns of player interaction and transformations of game structure

We will now present the results of analyses that are specific to each version of the game DECO. In each case, the analysis proceeds as follows:

- quantitative indicators are defined to measure the degree of congruence (or non congruence) of the children's game playing behavior with the competitive or cooperative structure implied by the rules of the game; modes of interaction resulting in transformations of game structure are described;
- the relationship between the indicators of congruence and two variables described previously - CONMUT and DECOMP - is examined by regression analysis,
- on the basis of both quantitative indicators and qualitative elements appearing in the observation protocols (in particular : global observations by the experimenters, content of the children's verbal interactions, sequences of behavioral events), different profiles of player interaction are identified.

For the analyses presented here, no systematic differences were found between the two grades; data are therefore pooled across grades.

The competitive version of DECO

For this version, two quantitative indicators are considered. A measure of congruence of the players' behavior with the game structure is provided by the indicator COMPET: % of turns with behaviors showing the players' awareness of the competitive structure of the game, i.e., remarks such as '*I'm going to beat you*', '*With that lucky draw, you're bound to win*'; gestures such as counting the chips in anticipation of the final scores, attempts to win by cheating. A measure of implicit transformation of the competitive structure of the game is given by the indicator SUGSOLP: % of turns in which the observing player offers a suggestion (e.g., '*You should use your 3 and 4*') or a positive sollicitation (e.g., '*You can do better than that*') that is likely to help his opponent increase the number of chips placed on the board, and thus improve his chances of winning.

As shown in Table 2, the manifestations of competitive behavior vary greatly in frequency from one pair of players to another (range of COMPET: 0-78%). The tendancy to transform the competitive game structure (by offering potentially helpful suggestions to one's opponent) is observed for all pairs of players, but shows a substantial degree of variation (range of SUGSOLP: 13-65%). This implies that in competitive games played by second and third graders, there is often a less pronounced competitive atmosphere than is typically the case of competition involving older children or adults.

Although it is not coherent with the aim of winning the game to offer helpful suggestions to one's adversary, this type of behavior does not necessarily imply a well-defined cooperative intention on the part of second- and third-grade children. In some cases, the child does not seem to grasp the relationship between his action at a given turn and the overall outcome of the round. In other cases, the suggestions seem to be motivated by impatience: the child helps his opponent to finish so he can have his own turn. This means that transformations of game structure can occur without the children being fully aware of their implications. Interviews with the players at the end of the sessions show that virtually all children want to win, but do not realize that their behavior is sometimes inconsistent with this goal.

A multiple regression of the variables CONMUT and DECOMP on the indicators COMPET and SUGSOLP showed that neither the degree of competition manifested by the children, nor their tendancy to help their opponent, has a systematic effect on the frequency of mutual control behavior or on the adequacy of decomposition strategies. For descriptive purposes, the correlations between these four variables are shown in Table 2. The lack of relationship beween these variables is due primarily to the <u>diversity</u> of the patterns of player interaction, as illustrated by the five profiles described in Table 2. For each profile, an example is given of the COMPET and SUGSOLP scores for one pair of players, e.g., under profile 1, for group 2-8 (2nd grade, 8th pair), manifestations of competitive behavior occured at 58% of the turns, while suggestions/sollicitations offered to the opponent were observed at 25% of the turns.

Table 2 : Patterns of game play : competitive version of DECO
(n - 16 pairs of players)

Indicator	mean	standard dev.	range
COMPET	34.3	21.3	0-78
SUGSOLP	35.7	14.8	13-65
CONMUT	71.0	17.2	40-95
DECOMP	33.1	2.8	28-37

Correlation matrix

	COMPET	SUGSOLP	CONMUT	DECOMP
COMPET	1.00	.22	.31	-.24
SUGSOLP		1.00	.27	-.40
CONMUT			1.00	.17
DECOMP				1.00

Note : all correlations are non significant at $p < .05$

Profile of player interaction	Description/Example
1. active competition	frequent manifestations of competitive behavior, relatively infrequent suggestions offered to opponent (Ex. Group 2-8 : COMPET = 58, SUGSOLP = 25)
2. tacit competition	close adherance to rules but low level of verbal interaction: few competitive remarks and few suggestions (Ex. Group3-4 : COMPET = 10, SUGSOLP = 13)
3. dynamic interplay	frequent manifestations of competitive behavior coupled with frequent constructive interactions with opponent (suggestions, encouragements) (Ex. Group 2-5 : COMPET = 58, SUGSOLP = 45)
4. mutual assistance	suggestions offered to opponent are more frequent than competitive behaviors; suggestions stimulate opponent's search activity; active participation of both players despite differences in math. ability (Ex. Group 3-2 : COMPET - 18, SUGSOLP - 30)
5. playing against oneself	frequent suggestions by a stronger player to his weaker opponent lead to the former "taking over" the latter's turns; stronger player is thus in competition with himself (Ex. Group 2-6 : COMPET - 13, SUGSOLP - 65)

The first two profiles are congruent with the competitive structure of the game. Profile 2 (tacit competition) is close to the adult style of competition with little or no verbalization, whereas profile 1 (active competition) entails frequent, explicit references to the competitive structure of the game. Profile 3 (dynamic interplay) is characterized by a high level oı competitive behavior coupled with frequent constructive suggestions offered to the other player; the interaction between the players shows more dynamic qualities (flexibility, mutual stimulation) than in other profiles. Profiles 4 and 5 show a more clear-cut departure from the competitive structure of the game, as evidenced by the fact that suggestions and positive sollicitations offered to the opponent are considerably more frequent than manifestations of competition (i.e., SUGSOLP > COMPET). There is, however, a major difference between these two latter profiles. In profile 4 (mutual assistance), the suggestions offered by one player stimulate the other's search for an optimal decomposition and there is active participation of both players, despite differences in their ability to carry out the mathematics operations. In profile 5 (playing against oneself), nearly all suggestions come from one stronger player who gradually "takes over" the turns of his opponent; this means that the structure of competition between two players degenerates into a situation where one player is in reality competing with himself on alternate turns.

Given five distinct profiles of game playing behavior and 16 pairs of players, it is difficult to carry out a rigorous quantitative analysis of the effect of the profiles on game outcomes, as measured by DECOMP. Examination of the available data leads, however, to the tentative conclusion that the profiles have little or no systematic impact on the adequacy of the decomposition strategies applied during the game. Profiles 1, 2, 3 and 4 appear to be equally likely to lead to appropriate outcomes, although a slight advantage may exist for profile 3 in which there is a high level of both competitive and helping behavior. In the case of profile 5, it is obvious that the weaker player is unlikely to develop mathematics skills if he is not actively involved in the game, but this negative outcome does not show up in his DECOMP score which is largely the result of his opponent's rather than his

own efforts.

The cooperative version of DECO

The degree of congruence of the players' behavior with the game structure is measured by an indicator (COLLAB) based on a classification of the players' level of collaboration at each turn:

- level 1: absence of collaboration (all operations - try-outs, proposals, verifications - are carried out by one player),
- level 2: parallel participation (operations are carried out by each player, but there is no concertation between players),
- level 3: minimal collaboration (the players coordinate their actions with respect to one operation during the turn),
- level 4: strong collaboration (the players coordinate their actions with respect to several operations during the turn).

For each level a corresponding number of points is attributed; COLLAB equals the sum of these points for 20 turns.

Examination of the protocols provides evidence of several types of behaviors that are not coherent with the cooperative version of DECO. Although these behaviors are considered in the subsequent definitions of game playing profiles, they do not lend themselves to measurement by a quantitative indicator, as was the case for SUGSOLP under the competitive version of DECO.

The data in Table 3 shows that the degree of collaboration between partners differs considerably from one pair of players to another (range of COLLAB: 40 to 78 points). The regression of variables CONMUT and DECOMP on COLLAB shows that the degree of collaboration between players is strongly related to their tendancy to engage in mutual monitoring and control ($r = .89$), but does not affect the adequacy of their decomposition strategies. In order to understand why lack of cooperation between partners does not lead to negative outcomes, it is necessary to examine the profiles of game playing behavior for this version of DECO.

Table 3 : Patterns of game play : cooperative version of DECO
(n - 16 pairs of players)

Indicator	mean	standard dev.	range
COLLAB	64.4	10.6	40-78
CONMUT	64.1	20.8	25-95
DECOMP	34.1	2.3	31-39

Correlation matrix

	COLLAB	CONMUT	DECOMP
COLLAB	1.00	.89 *	.16
CONMUT		1.00	.18
DECOMP			1.00

* significant correlation ($p < .05$)

Profile of player interaction	Description/Example
1. active collaboration	excellent cooperation on all tasks, active participation of both players, constructive exchanges of proposals (Ex. Group 3-5: COLLAB = 78, dist.: 18-2-0-0)
2. tacit collaboration	steady collaboration but with a relatively low level of verbal interaction (Ex. Group 2-7: COLLAB = 71, dist.: 16-6-0-1)
3. alternation	low level of cooperation; tendancy to divide up the tasks rather than to collaborate on same tasks; alternation of responsability for successive turns (Ex. Group 3-2: COLLAB = 40, dist.: 4-4-1-11)
4. one-man team	low level of cooperation; one player dominates all aspects of the game, makes all proposals even if a mechanical role is attributed to the other player (e.g., placing the chips on the board) (Ex. Group 2-6: COLLAB = 54, dist.: 5-7-5-3)

Four profiles have been identified and are described in Table 3. For each profile, an example is given of the COLLAB score of one group of players and the distribution of its 20 turns by level of collaboration is indicated, e.g., for profile 1, group 3-5 (3rd grade, 5th pair), strong collaboration was observed at 18 turns, minimal collaboration at 2 turns, parallel participation and absence of collaboration at 0 turns each.

The first two profiles are congruent with the cooperative structure of the game. In profile 1 (active collaboration), there is frequent discussion, and sometimes even temporary disagreement, regarding the operations to be undertaken, whereas in profile 2 (tacit collaboration), the players reach agreements rapidly with relatively little verbal interaction. Profiles 3 and 4 both reflect transformations of the cooperative structure implied by the rules of the game. This is particularly clear in the case of profile 3 (alternation) where the players tend to alternate turns, like in the competitive version of DECO; moreover, their verbal comments (e.g., "*Wait, I haven't finished*", "*That will make 4 or 5 for you?*") refer to individual rather than to team efforts and outcomes. Profile 4 (one-man team) is similar to profile 5 for the competitive version of DECO in the sense that one player dominates all aspects of the game and the other is not actively involved in the operations of finding and verifying appropriate decompositions.

As was the case for the competitive version of DECO, although there are too few cases for each profile to carry out a quantitative analysis, the different patterns of playser interaction do not appear to have a systematic impact on game outcomes, as measured by DECOMP (adequacy of decomposition strategies). For profile 3, as long as the two players are both fairly competent, there is no reason for their results to be very different from those generally obtained by children under the competitive version of DECO. In the case of profile 4, an adequate DECOMP score is assured by the stronger player; the lack of involvement and lack of competency of the weaker player does not show up in the game outcome, but it is obvious that, in the long run, profile 4 is likely have a negative impact of the weaker student's opportunity for acquiring mathematics skills in the context of instructional games.

CONCLUSIONS AND PRATICAL IMPLICATIONS

The results of this study lead to the following conclusions with respect to the use of games in mathematics instruction in second and third grades:

1. For the game under consideration, there are few differences between second- and third-grade students. Third graders have a lower level of verbal interaction when playing the competitive version of DECO, and their decomposition strategies are slightly more adequate on the average, but overall patterns of play behavior are quite similar for the two grades. This lack of differences between grades is probably due to the fact that children of both grades are in a stage of consolidation with respect to the operations of number decomposition initially studied in first grade. Between-grade differences are likely to be be more pronounced when students are at different stages of learning with respect to the concepts or operations dealt with in a game.

2. The competitive or cooperative structure of interdependence defined by the rules of the game has less impact than might be expected on the basis of previous research dealing with competition and cooperation in other learning situations. Although the cooperative version of the game encourages considerably more verbalization on the part of the children, game structure has little or no effect effect on other aspects of player behavior, such as mutual monitoring and control behavior, or on the adequacy of game outcomes. This means that there is no compelling reason for teachers to prefer one game structure over the other; both competitive and cooperative versions of a game can be proposed to children and the choice can be left to their personal preference.

3. The lack of systematic impact of game structure is due in large part to the high degree of variation in game behavior from one pair of players to another. For each version of the game, it was possible to identify four or five distinct profiles of player interaction. In each case, certain profiles entail transformations of the game structure either by the introduction of cooperative elements of play in the competitive version or, although less frequently, by the introduction of competitive elements in the cooperative

version. Diverse profiles of player interaction do not appear to lead to marked differences in the adequacy of game strategies. However. adequate outcomes can sometimes mask cases where one player dominates all aspects of the game; this situation, if frequently repeated, would undoubtedly have a negative impact on the weaker student's opportunity for learning.

It would be useful for elementary school teachers, who often assume that their students carry out school tasks exactly as proposed, to be made aware of the diversity of the patterns of behavior that can occur with any given game structure. Although this diversity can be seen as a generally positive form of enrichment of the instructional situation, teachers should be attentive to the fact that dysfunctional patterns of behavior can sometimes occur without there being an obvious effect on game outcomes.

In summary, the results of our study suggest that games can be considered as a form of "adaptive" instruction (Waxman *et al*, 1985) in which there is a very sizeable range of player-induced adaptations of the pre-established structure. In the usual forms of adaptive instruction, the differentiation of learning conditions is a result of teacher decisions; in games, adaptation is a consequence of differing patterns of peer interaction.

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DECO

ANNEX A

MATERIEL :

1 PLANCHE
10 PIÈCES ORANGES : NOMBRES À DÉCOMPOSER
1 SAC CONTENANT DES PIÈCES JAUNES : NOMBRES À UTILISER POUR LA DÉCOMPOSITION
ET DES PIÈCES-JOKER : PIÈCES SANS NOMBRE INSCRIT
1 CRAYON POUR INSCRIRE DES NOMBRES SUR LES PIÈCES-JOKER

BUT DU JEU :

DÉCOMPOSER DES NOMBRES EN UTILISANT UN MAXIMUM DE PIÈCES : POSER LE PLUS GRAND NOMBRE DE PIÈCES JAUNES SUR LA PLANCHE, ET EN GARDER LE MOINS POSSIBLE À LA FIN DE LA PARTIE.

VERSION COMPETITIVE POUR DEUX JOUEURS :

RÈGLES :

AU DÉBUT DE LA PARTIE :

- MÉLANGER ET POSER À L'ENVERS TOUTES LES PIÈCES ORANGES (LE NOMBRE INSCRIT NE DOIT PAS ÊTRE VISIBLE)
- TIRER 10 PIÈCES JAUNES DU SAC POUR CHAQUE JOUEUR
- DÉCIDER QUELLE PARTIE DE LA PLANCHE SERA ATTRIBUÉE À CHAQUE JOUEUR ET QUI COMMENCE

A CHAQUE TOUR :

- CHOISIR UNE PIÈCE ORANGE ET LA POSER SUR LA PARTIE CENTRALE DE LA PLANCHE
- CHOISIR UNE OU PLUSIEURS PIÈCES JAUNES POUR FAIRE AU TOTAL "LA MÊME CHOSE" QUE LE NOMBRE INSCRIT SUR LA PIÈCE ORANGE
- ALIGNER LES PIÈCES CHOISIES À CÔTÉ DE LA PIÈCE ORANGE
- SI LES NOMBRES À DISPOSITION NE PERMETTENT PAS D'EFFECTUER LA DÉCOMPOSITION :
  . TIRER UNE PAR UNE DES PIÈCES SUPPLÉMENTAIRES
- POUR UTILISER UNE PIÈCE-JOKER :
  . INSCRIRE N'IMPORTE QUEL NOMBRE ENTRE 0 ET 9 (0 ET 5 POUR LES ÉLÈVES DE 1P)

- VÉRIFIER À LA FIN DE CHAQUE TOUR QUE LA COMBINAISON POSÉE PAR LE JOUEUR ADVERSE EST CORRECTE

PÉNALISATION :

SI LA DÉCOMPOSITION EST INCORRECTE REDONNER LES PIÈCES POSÉES AU JOUEUR ET RETOURNER LA PIÈCE ORANGE POUR INDIQUER LE TOUR PERDU.

A LA FIN DE LA PARTIE :

- ENLEVER UNE PIÈCE POSÉE SUR LA PLANCHE POUR CHAQUE PIÈCE INUTILISÉE
- COMPTER POUR CHAQUE JOUEUR LE NOMBRE DE PIÈCES RESTANTES : CELUI QUI OBTIENT LE PLUS GRAND SCORE GAGNE LA PARTIE.

VERSION COOPERATIVE POUR DEUX JOUEURS

MÊME PRINCIPE DE JEU. AU DÉBUT DE LA PARTIE, 10 PIÈCES SONT TIRÉES DU SAC POUR LES DEUX JOUEURS QUI FORMENT UNE ÉQUIPE. IL N'Y A PAS DE PÉNALISATION COMME DANS LA VERSION COMPÉTITIVE. LES JOUEURS DOIVENT DÉCIDER ENSEMBLE TOUT AU LONG DE LA PARTIE DES DÉMARCHES À EFFECTUER, CONTRÔLER QUE LES RÉSULTATS SONT CORRECTS. LA PARTIE SE JOUE SUR 5 TOURS. A LA FIN DE LA PARTIE, ON ENLÈVE UNE PIÈCE POSÉE POUR CHAQUE PIÈCE INUTILISÉE, PUIS ON CALCULE LE SCORE DE L'ÉQUIPE QUI CORRESPOND AU NOMBRE DE PIÈCES RESTANTES. LE BUT DU JEU EST D'AMÉLIORER LE SCORE DE L'ÉQUIPE D'UNE PARTIE À L'AUTRE.

CHAMP NUMERIQUE (TEL QUE DÉFINI DANS NOTRE RECHERCHE)

POUR LES ÉLÈVES DU DEGRÉ	1P	2P - 3P
- NOMBRES À DÉCOMPOSER (PIÈCES ORANGES)	JUSQU'À 10	JUSQU'À 20
- NOMBRES UTILISÉS POUR LES DÉCOMPOSITIONS (PIÈCES JAUNES)	0 À 5	0 À 9

D'AUTRES VARIATIONS DU CHAMP NUMÉRIQUE SONT POSSIBLES, SELON LE NIVEAU DES ÉLÈVES.